1. (25) Packet switching. Assume no acknowledgements are required. For the purpose of this problem, header length is 40 bits.

a. (10) An network of 25 Mbps ATM links transfers 424 bit packets via 11 switches before arriving at the destination. Since ATM is a virtual circuit switching method, there is a 1.5 ms setup time. Propogation delay is 50 μs per hop. What data throughput can we achieve if we want to transfer a 15 KByte file?

b. (10) Suppose instead of ATM in part (a), we used a datagram (IP) method for transfering packets, where each packet is 12,040 bits long. What is the data throughput in this case (all other factors remaining the same)?

c. (5) Which method gives a higher data throughput? Give an intuitive explanation as to why.

Refer to (9.2) Note: 11 switches ⇒ 12 hops

$$T_D = \left\lceil \frac{L}{P-H} \right\rceil \frac{P}{R} + D + (N-1)\left(\frac{P}{R} + D\right)$$

a) $T_V = S + T_D$

$$= 15(10)^{-3} + \left\lceil \frac{15(10)^3 \cdot 8}{(424-40)} \right\rceil \cdot \frac{424}{25(10)^6} + 5(10)^{-5} + 11\left(\frac{424}{25(10)^6} + 5(10)^{-5}\right)$$

$$= 15(10)^{-3} + 5.35(10)^{-3} + 737(10)^{-4}$$

$$= 7587(10)^{-3} \text{ sec}$$

$$\text{Data Throughput} = \frac{\text{TOTAL DATA}}{T_V} = \frac{120000}{7.587(10)^{-3}} = 15.82 \text{ Mbps}$$

b) $$T_D = \left\lceil \frac{15(10)^3 \cdot 8}{(12040-40)} \right\rceil \frac{12040}{25(10)^6} + 5(10)^{-5} + 11\left(\frac{12040}{25(10)^6} + 5(10)^{-5}\right)$$

$$= 487(10)^{-3} + 5.85(10)^{-3}$$

$$= 10.72(10)^{-3} \text{ sec}$$

$$\text{Data Throughput} = \frac{120000}{10.72(10)^{-3}} = 11.2 \text{ Mbps}$$

c) The ATM architecture is higher in this case because the smaller frame size is delayed for less amount of time before retransmission at each intermediate node

2. (25) Multiple choice:

a. (3) FDDI uses an early release token method due to:
   a) the need to maintain a satisfactory level of utilization;
   b) the larger packet size of the token;
   c) the incorporation of both synchronous and asynchronous data types;
   d) the use of a data priority scheme.

b. (3) On a standard token ring network with $a = 0.5$, a station transmits a frame. The station will release the token...
   a) when the leading edge of the frame arrives back at the station of origin;
   b) when the trailing edge of the frame arrives back at the station of origin;
   c) when the trailing edge of the frame leaves the station of origin;
   c) when the trailing edge of the frame arrives at the destination.

c. (2) Which of the following is not an access method used by wireless LANs?
   a) CSMA/CD (comb)b) CDMA c) CSDA d) CSMA/CA

d. (3) Which of the following stations on a token ring network can lower the priority of a token?
   a) The station that made the higher priority reservation.
   b) The station that receives the higher priority frame.
   c) The next station to make a reservation.
   d) The station that raised the priority of the token.

e. (2) Gigabit Ethernet is intended to be a high-speed LAN backbone spanning large campuses.
   a) True b) False

f. (2) Although the least expensive to implement, time-division switches suffer from blocking conditions.
   a) True b) False

g. (3) Which of the following standards allows the greatest distance end stations?
   a) 10Base5 b) 10BaseT c) 100BaseT d) 1000BaseSX

h. (2) On an Ethernet network, when a station detects a collision the next thing it does is:
   a) delays for some random amount of time;b) goes into receive mode;
   c) keeps transmitting; d) notifies the offending station.

i. (2) Which of the following is not a standard transmission method for wireless LANs?
   a) Direct Sequence Spread Spectrumb) Infrared
   c) Frequency Hopping Spread Spectrumc) Laser

j. (3) When a central station on a DQDB network transmits a request to send data, which stations on the network increment their RCs?
   a) Those with data currently queued to send;
   b) Those in the same direction as the intended recipient;
   c) All stations;
   d) Those in the opposite direction as the intended recipient.

3. (25) Short answers:

a. (5) Per the IEEE 802 definition of exponential backoff, what is the probability that a station delays four slot times on the fifth retransmission attempt?

$\frac{1}{2^5} = \frac{1}{32}$

b. (7) Name all of the layers of the OSI network protocol architecture model.

APPLICATION, PRESENTATION, SESSION, TRANSPORT, NETWORK, DATA LINK, PHYSICAL

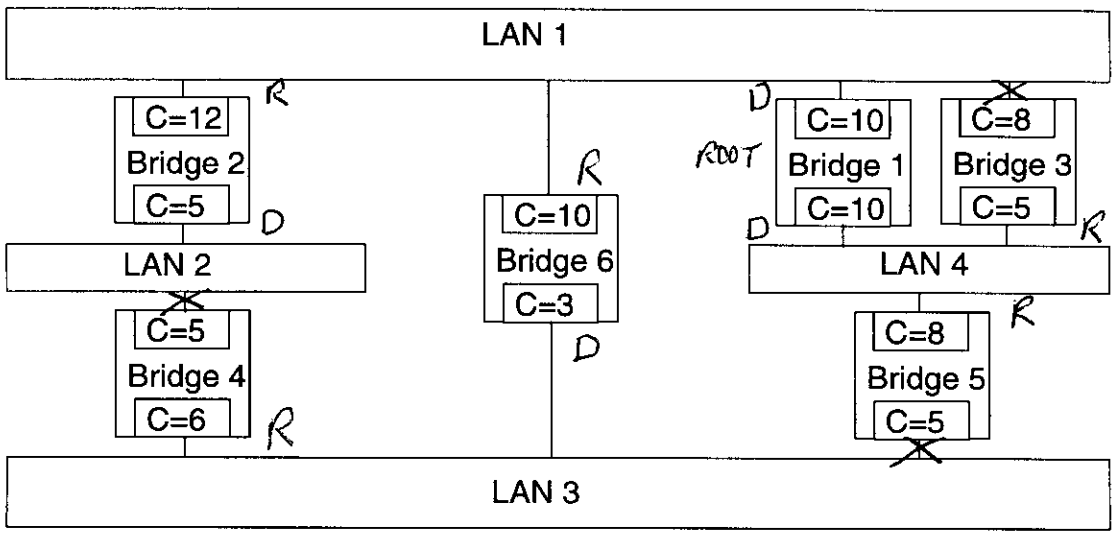
Using the spanning tree algorithm, develop a routing hierarchy for the interconnected LANs shown below.

c. (1) Identify the root bridge.

d. (4) Identify root ports for all bridges.

e. (4) Identify designated ports for each LAN.

f. (4) Identify disabled ports upon completion of the configuration.



4. (25) LAN Performance.

a (15) A 10 station 10 Mbps CSMA/CD UTP network spans 1500 m and is restricted to transmitting 512 bit frames. What percentage of time on this network is occupied by collisions or no transmission?

$N = 10; \quad a = \frac{Rd}{LV} = \frac{10(10)^6 \cdot 1500}{512 \cdot 2(10)^8} = 0.146$

Assume $P = \frac{1}{N} \Rightarrow A = (1 - \frac{1}{N})^{N-1} = 0.9^9 = 0.387$

$$\frac{\text{TIME IN COLLISION/NO TRANSMISSION}}{\text{TOTAL TIME}} = \frac{\frac{1-A}{A}}{\frac{1}{2a} + \frac{1-A}{A}} = \frac{1.58}{3.42 + 1.58}$$

$$= 0.316$$

b. (10) A 15-station token ring network of total length 4 km sprawls between two buildings. The data rate of this network is the standard 16 Mbps. Assume frames are strictly limited in this case to 246 bits. What is the system capacity normalized throughput (line utilization) for this network?

$N = 15; \quad a = \frac{Rd}{LV} = \frac{16(10)^6 \cdot 4000}{246 \cdot 2(10)^8} = 1.3$

$a > 1 \Rightarrow U = \frac{1}{a + \frac{a}{N}} = \frac{1}{1.3 + \frac{1.3}{N}} = 0.72$